ABRIKOSOV,A.A.

Compton effect and mutual scattering of particles at high energies in quantum electrodynamics and pseudoscalar theory. Dokl. AN SSSR 102 no.6:1097-1098 Je'55. (MLRA 8:10)

1. Institut fizicheskikh problem imeni S.I.Vavilova Akademii nauk SSSR. Predstavleno akademikom L.D.Landau
(Particles, Elementary--Scattering) (Quantum theory) (Electrodynamic theory)

Abrikosov, A. A.

16, 315) on the asymptotic behavior of Green's functions in quantum field theory are here re-derived, using a modified form of high-momentum cut-off. Instead of a single cut-off momentum Λ, the authors use one cut-off Λ_1 for the Bose field and another Λ_2 for the Fermi field. The results are the same as before.

PEIERLS, Rudolf Ernst, 1907- ; ABRIKOSOV, A.A. [translator]

[Quantum theory of solids] Kvantovaia teoriia tverdykh tel. Moskva, Izd-vo inostr.lit-ry, 1956. 259 p. Translated from the English. (MIRA 13:3)

(Quantum theory) (Solids)

Abrikosov A.A.

USSR/Theoretical Physics - Quantum Electrodynamics B-5

Abst Journal : Referat Zhur - Fizika, No 12, 1956, 33771

Author : Abrikosov, A. A.

Institution : Institute of Physical Problems, Academy of Sciences USSR

Title : Concerning the Infrared Catastrophe in Quantum Electrodynamics

Original Periodical : Zh. Experim. i Teor. Fiziki, 1956, 30, No 1, 96-108

Abstract : Report on the investigation of the infrared catastrophe, leading in quantum electrodynamics to supplementary discrepancies in the region of the momenta k of the virtual quanta k^2 close to zero, and related with the possibility of radiation in various processes of supplementary soft quanta that cannot be controlled by the experiment. By summing the principal diagrams of the perturbation-theory series, the Green's function G(t) of the electron was obtained in the vicinity $p^2 \sim m^2$, in which an

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Abst Journal : Referat Zhur - Fizika, No 12, 1956, 33771

additional singularity appears compared with the simple pole for the Green's function of the electron that does not interact with the electrodynamic field. Also computed was the apex part $\Gamma_{\mu}(p,q,l)$ for the case $(pq) \gg p^2 - m^2$, $q^2 - m^2$. A convenient method was developed to generalize the Feyman diagrams, permitting relatively simple calculation of the probability of processes, containing a large number of real pairs and quanta. This method displays great similarity to the usual technique for virtual processes in problems where the detailed characteristics of the real particles are of no interest. With the aid of the technique developed the probability was calculated of the supplementary radiation of many quanta upon scattering, for which the well-known Poisson equation is obtained.

ABRIKOSOV, A.A.

539.166.74

5373. THE COMPTON EFFECT AT HIGH ENERGIES.

A.A.Abrikosov.

~~Zh. eksper. teor.~~ Fiz., Vol. 30, No. 2, 386-98 (1956). In Russian.

Analysis of effects obtained by summation of diagrams having, for a given power of e^4, a maximum power of $\ln(\omega/m)$ which corresponds to $[e^4\ln^4(\omega/m)]^n$; here e and m = charge and mass of electron, ω = energy of photon. The following results were obtained: Formulae for single and multiple effects; angular and energy distribution of the secondary quanta; probability of secondary electron possessing a given energy. A peculiar variation of scattering at small angles has been found which leads to variation of the refractive index of the medium for energetic photons. A.

АБРИКОСОВ, А. А.

1952

SCATTERING OF HIGH ENERGY [illegible]

ABRIKOSOV, A. A.

AUTHOR: ABRIKOSOV, A.A. 56-6-22/56

TITLE: On the Magnetic Properties of Supraconductors of the Second Group. (O magnitnykh svoystvakh sverkhprovodnikov vtoroy gruppy, Russian)

PERIODICAL: Zhurnal Eksperim. i Teoret. Fiziki, 1957, Vol 32, Nr 6, pp 1442-1452 (U.S.S.R.)

ABSTRACT: The magnetic properties are theoretically derived for a supraconductor in form of a full cylinder, which is located in a longitudinal field. In this way it is possible, for a number of alloys (as e.g. Pb + Tl, Pb + In) to explain their magnetic properties with $\varkappa > 1/\sqrt{2}$. ($\varkappa$ denotes the parameter determining the surface voltage between the normal phase of the supraconductive phase). The factor $< 1/\sqrt{2}$ and $> 1/\sqrt{2}$ respectively is, according to the GINSBURG-LANDAU theory, a criterion as to whether the supraconductor belongs to the "first" or to the "second" group. (With 1 Table, 1 Illustration, and 6 Slavic References).

ASSOCIATION: Institute for physical Problems of the Academy of Science of the U.S.S.R.

PRESENTED BY:

SUBMITTED: 15.11;1956

AVAILABLE: Library of Congress

Card 1/1

ABRIKOSOV, Aleksey Alekseyevich, doktor fiziko-matematicheskikh nauk; KHALATNIKOV, Isaak Markovich, doktor fiziko-matematicheskikh nauk, professor; FAYNBOYM. I.B., redaktor; GUBIN, M.I., tekhnicheskiy redaktor

[Newly discovered properties of elementary particles] Novye svoistva elementarnykh chastits. Moskva, Izd-vo "Znanie," 1957. 15 p. (Vsesoiuznoe obshchestvo po rasprostraneniiu politicheskikh i nauchnykh znanii. Ser.8, no.20) (MLRA 10:7)

(Particles, Elementary)

25-4-3/34

SUBJECT: USSR/General Nuclear Research

AUTHOR: Abrikosov, A.A., Doctor of Physicomathematical Sciences
Khalatnikov, I.M., Professor of Physicomathematical Sciences.

TITLE: Interaction between elementary particles (Vzaimodeystviye Elementarnykh Chastits)

PERIODICAL: Nauka i Zhizn' April 1957, # 4, pp 9-10 (USSR)

ABSTRACT: This article deals with the very important problem of modern physics - the study of interactions between elementary particles. Without a detailed theory based on such research it is impossible to understand the nature of the forces acting in atomic nuclei, their structure, and the physics of numerous nuclear processes. Physicists all over the world are interested in the theory on the interaction of elementary particles. The latest physical theory is a development in the direction of former ideas. The basic object of studies covering contemporary physics are the elementary particles of the matter we are surrounded by. One of these particles is the electron.
L.D. Landau, I.Ya. Pomeranchuk and the authors of this article were the first to find methods of analyzing the interactions

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TITLE: Interaction between elementary particles (Vzaimodeystviye Elementarnykh Chastits) 25-4-3/34

of arbitrary forces. The results were quite unexpected. It was established that the interaction becomes weaker when the area is smaller on which it is spread. The situation changes entirely with regard to nuclear forces, i.e. forces acting between particles inside an atomic nucleus (protons and neutrons). Those interactions are very strong.

ASSOCIATION:

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SUBMITTED:

AVAILABLE: At the Library of Congress

Card 2/2

56-4-33/52

AUTHOR KHALATNIKOV, I.M., ABRIKOSOV, A.A.

TITLE The Thermodynamics of Liquid He^3 (Termodinamika zhidkogo He^3. Russian)

PERIODICAL Zhurnal Eksperim. i Teoret. Fiziki, 1957, Vol 32, Nr 4, pp 915 - 919 (U.S.S.R.)

ABSTRACT

Starting out from Landau's model of the Fermi liquid (L. Landau, Zhurn. eksp. i teor. fis., Vol 39, p 1058 (1956), the paper under review investigates the thermodynamics of liquid helium. In case of small deviations of the distribution function from its equilibrium value at T = 0 it is possible to represent the excitation energy in the form of $\mathcal{E} = \mathcal{E}(p) + \int f(p,p') \nu (p') d\tau'$ $d\tau = g dp_x dp_y dp_z / (2\pi\hbar)^3$. In this context, we have $\nu = n - n_0$, and g denotes the statistical equilibrium, f does not depend on the spin. In the usually accepted model of the ideal gas of the excitations, the energy $\varepsilon(p)$ is written in the from of $p^2/2m$, with m denoting a certain effective mass. But the results obtained with this form of the spectrum are not in very good agreement with the experimental data. Therefore the authors of the paper under review investigate for $\varepsilon(p)$ another function proposed by L.D. Landau, namely $\mathcal{E}(p) = (p - p_0)^2 / 2m$, with m denoting the effective mass. In this case, the distribution function is a T = 0 not a sphere in the impulse space, but rather a spherical layer. In the paper under review its an-

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APPROVED FOR RELEASE: 03/20/2001 CIA-RDP86-00513R000100220016-9"

The Thermodynamics of Liquid He^3 56-4-33/52

thors consider the thickness of this layer to be small as compared to its radius p_o. In the case of the spectrum $\varepsilon(p) = (p-p_o)^2/2m$, the temperature of the Fermi liquid is suitable, as a principle, only for such temperatures at which the deviations from the distribution function corresponding to zero are small. In the model of the ideal gas, this corresponds to the temperatures $T \ll T_e$, with T_e denoting the temperature of the degeneration. In this context there exists a temperature range, namely $T > T_e$, in which the deviation of the distribution function corresponding to zero is small. This circumstance makes possible the computation of the thermodynamic quantities in the Fermi region and in the Boltzmann region. The above-mentioned spectrum corresponds in a better way to the experimental data than the model of the ideal gas. On the other hand, this improvement is not so considerable as to exclude the model of the ideal gas for He^3. Then the paper under review concludes by discussing the heat capacity, the entropy and the magnetic susceptibility in greater detail. (3 reproductions).

ASSOCIATION Not given

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Card 2/2

ABRIKOSOV, A.A.

USSR/Atomic and Molecular Physics - Low- Temperature Physics D-5

Abs Jour : Ref Zhur - Fizika, No 1, 1958, 786

Author : Abrikosov, A.A., Khalatnikov, I.M.

Inst : Institute of Physical Problems, Academy of Sciences, USSR

Title : Theory of Kinetic Phenomena in Liquid He^3.

Orig Pub : Zh. eksperim i teor. fiziki, 1957, 32, No 5, 1083-1091

Abstract : On the basis of the theory of the Fermi liquid, previously developed by Landau, the coefficient of viscosity (η) and of heat conduction ($\varkappa$) are calculated for liquid He^3. A calculation, made under the assumption that the distribution in the ground state is a Fermi sphere, gives a dependence $\eta \sim T^{-2}$ for the viscosity coefficient. The order of quantity received is $\eta \sim 1 \times 10^{-6} T^{-2}$ poise. The temperature dependence of $\varkappa$ is determined by the formula $\varkappa \sim T^{-1}$, and its numerical value is approximately

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USSR/Atomic and Molecular Physics - Low Temperature Physics D-5

Abs Jour : Ref Zhur - Fizika, No 1, 1958, 786

estimated to be $\sim$ 40/T erg/cm-sec-deg. An analysis of the limits of the applicability of the resultant expressions shows that the deductions of the theory are correct at temperatures below 0.1° K. It is shown that in the case when the distribution at $T = 0$ is a thin spherical layer, the temperature dependence of η and $\varkappa$ should be similar. Only the second viscosity ζ would have a different numerical value. An experimental determination of this quantity would permit an estimate of the form of the excitation spectrum of liquid He^3.

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ABRIKOSOV, A. A.

AUTHOR: Abrikosov, A.A., Khalatnikov, I.M. 56-5-13/46

TITLE: On a Model of a Non-Perfect Fermi Gas (Ob odnoy modeli neideal'nogo Fermi-gaza)

PERIODICAL: Zhurnal Eksperim. i Teoret. Fiziki, 1957, Vol. 33, Nr 5, pp. 1154-1159 (USSR)

ABSTRACT: Computations by Huang (ref. 1) and other scientists of the properties of non-perfect Bose- and Fermi gases consisting of particles the measurements of which are small compared to their average wave length, are extremely voluminous. Another method of computation is now proposed by means of which it is comparatively easy to compute the thermodynamical quantities of Huang's model for the case of the Fermi statistic.
The energy of the basic state (E) and the effective mass (m/m^*) of the excitation of a Fermi gas is:

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On a Model of a Non-Perfect Fermi Gas 56-5-13/46

$$E = \int \mu \, dN = E^{(0)} + \frac{\pi a \hbar^2}{m} N^2 \left[1 + \frac{6}{35} \left(\frac{3}{\pi} \right)^{1/3} a N^{1/3} (11 - 2 \ln 2) \right]$$

and

$$\frac{m}{m^*} = 1 - \left(\frac{8}{15} \right) \left(\frac{3}{\pi} \right)^{2/3} (7 \ln 2 - 1) a^2 N^{2/3}$$

There are 1 figure and 6 references, 3 of which are Slavic.

ASSOCIATION: Institute for Physical Problems AN USSR (Institut fizicheskikh problem AN SSSR)

SUBMITTED: April 24, 1957

AVAILABLE: Library of Congress

Card 2/2

ABRIKOSOV, A.A.

AUTHOR KHALATNIKOV, I.M., ABRIKOSOV, A.A. 56-7-16/66

TITLE Dispersion of sound in a Fermi-liquid. (Dispersiya zvuka v Fermi-zhidkosti.- Russian)

PERIODICAL Zhurnal Eksperim. i Teoret. Fiziki 1957, Vol 33, Nr 7, pp 110-115 (USSR)

ABSTRACT On the basis of the theory of the FERMI liquid suggested by LANDAU the present paper investigates the absorption and the dispersion of sound vibration in such a liquid. Concrete computations are carried out here for liquid He^3. The kinetic equation for the excitations takes the form:

$$(\partial n/\partial t)+(\partial n/\partial \vec{r})(\partial \varepsilon/\partial \vec{p})-(\partial n/\partial \vec{p})(\partial \varepsilon/\partial \vec{r}) = I(n)$$

Here ε denotes the energy corresponding to one single excitation. The energy is a function of the density n of the excitations. The function ε is then specialized for small deviations of the distribution function from the FERMI distribution corresponding to the equilibrium. The vibrations of the density of the excitations n may be assumed to have only small amplitudes in the liquid. $n_1 = n - n_0$ may apply. The derivation $\partial n_0/\partial \varepsilon$ represents a δ-function. The propagation velocity of the undamped

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Dispersion of sound in a Fermi-liquid. 56-7-16/66

oscillations is determined by a transcendental equation which is dealt with more thoroughly in the appendix. The concrete computations for H^3 can be means of a function of the type $F = F_0 + F_1 \cos\vartheta$. At temperatures different from zero an ordinary sound will propagate in the FERMI liquid. A formula is explicitly given for the absorption of this sound at low frequencies ω. At low temperatures the total absorption of the sound depends on viscosity. The last-mentioned formula is true also in the case in which the frequency of the sound is low and satisfies the condition $\omega\tau \ll 1$ where τ denotes the time between the collisions of the excitations. τ is proportional to the square of the temperature. Also in the case $\omega\tau \gg 1$, however, vibrations in a FERMI liquid may propagate ("zero-sound") The equation for the determination of the complex sound velocity is derived and written down and describes the disperion of sound in a FERMI liquid. Next, the two border cases $\omega\tau \ll$ and $\omega\tau \gg$ are investigated more closely. In conclusion there follow a data on the absorption of the sound in a FERMI liquid at lowest temperatures ($\hbar\omega \gg kT$). In this quantum-like domain the absorption of the "zero-sound" does not depend upon the

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Disperion of sound in a Fermi-liquid. 56-7-16/66

temperature and is proportional to the square of the sound frequency.
(No Illustrations)

ASSOCIATION: Institute for Physical Problems of the Academy of Sciences of the U.S.S.R.
(Institut fizicheskikh problem Akademii nauk SSSR.- Russian)

PRESENTED BY: -

SUBMITTED: 11.12. 1956

AVAILABLE: Library of Congress.

CARD 3/3

Academy of Sciences USSR

30-58-4-4/44

AUTHOR: Abrikosov, A. A., Doctor of Physical-Mathematical Sciences

TITLE: The Problem of Superconductivity (Problema sverkhprovodimosti)

PERIODICAL: Vestnik Akademii Nauk SSSR, 1958, Nr 4, pp. 30-36 (USSR)

ABSTRACT: This phenomenon was discovered in the year 1911 by Kamerling-Onnes, who found out that the resistance of mercury suddenly decreases to zero at a temperature of about 4 °K. In the course of further investigations there were also determined other particulars. The author mentions a number of foreign scientists who dealt with the same problem but were not able to solve it completely. A. I. Shal'nikov, Ye. T. S. Eppl'yard and A. D. Mitsener, as well as D. Shenberg also worked on this problem. Besides the theoretical investigations there were also carried on experiments. Besides others, L. D. Landau in 1937 elaborated a complete theory about the intermediate stage of superconductors which was proved by the works of A. I. Shal'nikov and A. G. Meshkovskiy (1947-1949), as well as Yu. V. Sharvin (1957). By the theory of Ginzburg and Landau the author in 1957 succeeded in clearing the particulars of the magnetic behavior of superconductive alloys. As a lack of all

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these theories their phenomenologic character may be considered; this means that they do not base upon real microscopic assumptions about the state of electrons in the metal. That can be explained because in spite of a lot of research results, there was until 1957 no microscopic theory about superconductivity. In 1956 the American L. N. Cooper offered his idea about the formation of superconductivity by pointing out that if there is an attraction , little as it may be, between the electrons, those among them which lie on the small interval of the maximum energies must form combined pairs. By this way we have a totality of electron-pairs which, as regards their qualities, in many reasons are closely connected with helium atoms. In April 1957 Cooper, together with 2 other scientists, published a short note announcing the elaboration of superconductivity-theory and giving a lot of results. In June 1957 the complete article was reproduced in form of manuscripts. The Soviet physicist, N. N. Bogolyubov, Member of the Academy, who did not know this manuscript, in autumn 1957 because of the notes of Cooper worked out some methods about how to deal with this problem. One of them, as was shown later, agreed with the method of the three authors.

30-58-4-4-/44

The Problem of Superconductivity

This work is the basis for a lot of other already finished works. There is mentioned the work of V. V. Tolmachev, who investigated the Coulomb-repulsion between electrons. L. P. Gor'kiy came to the conclusions of the three authors by following a completely new method which is close to the methods of the quantum-theory of the field. B. T. Geylikman found the temperature dependence of the thermal conductivity of superconductors. A. A. Abrikosov, L. P. Gor'kiy and I. M. Khalatnikov in their work investigated the problem how superconducters behave in a high-frequency field. The author is sorry that there are only few informations about the success attained in this research domain abroad. Many problems should be solved by means of the new theory wherein the problem of the critical temperatures plays an important part. It would be important to know whether superconductors with a high critical temperature can be produced, e.g., of about the temperatures of liquid air. This would be of great practical importance. In their works S. V. Tyablikov and V. V. Tolmachev arrived at the conclusion that the critical temperatures must lie in the range of temperatures about the absolute freezing-point.

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The Problem of Superconductivity 30-93-4-4-/44

The problems of the critical fields and the qualities of superconductors which are contaminated by additions are still to be solved. There is reason to assume that the superconductivity will be of great practical use. Already now elements for calculating-machines are made from superconductors. Superconductors are also used in the radiotechnics.

1. Superconductivity--Temperature factors

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ABRIKOSOV, A. A.; KHALATNIKOV, I.

Modern theory on superconductivity. Usp. fiz. nauk. 6 no.4:551-591 Ag '58. (MIRA 11:10)

(Superconductivity)

ABRIKOSOV, A. A.

56-1-28/56

AUTHORS: Abrikosov, A. A., Khalatnikov, I. M.

TITLE: The Scattering of Light in a Fermi Fluid (Rasseyaniye sveta v Fermi-zhidkosti)

PERIODICAL: Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, 1958, Vol. 34, Nr 1, pp. 198-203 (USSR)

ABSTRACT: The present paper determines the distribution of the scattered light to the angles and to the frequencies. According to Landau (reference 1) oscillations of a certain type which are designated as "zero sound" can spread in a Fermi fluid at sufficiently low temperatures. Even at a temperature of 0,01° a frequency of more than 10^8 cycles is needed for the immediate observation of zero sound, which renders the performance of such an experiment very difficult. But an indirect method can also be suggested which consists of the observation of the Rayleigh scattering of light in liquid He^3. The observation of the frequency distribution of the scattered light principally makes possible the measurement of the speed of zero sound. Besides, the scattering of the light in a Fermi fluid has a number of specific features, wherefore the theoretical investigation

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The Scattering of Light in a Fermi Fluid 56-1-28/56

of this phenomenon, especially of the distribution of the intensities to the frequencies, is of interest. Due to the very small polarizability of the helium-atoms it may be assumed that the dielectric constant changes due to the fluctuation of density. In the range of those temperatures and frequencies where $\hbar\Delta\omega \geqslant kT$ applies the quantum effects must be taken into account in the averaging of all possible fluctuations. But for this purpose only the knowledge of the purely classical case is needed and then a certain corrective factor has to be introduced. The fluctuation of the "random force" contained in the kinetic equation is determined by the method suggested by Rytov (reference 5), Landau and Lifshits (reference 6). After the solution of this equation the fluctuations of the distribution function can then also be determined. The kinetic equation used here for the case of the Fermi fluid is explicitly written down. The authors are furthermore only interested in the case that the collisions can be disregarded. In this connection the exact form of the shock integral does not have to be known. But the velocity of modification of the entropy has to be determined. The course of the calculation is followed step by step. In this manner formulae for the calculation

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is followed step by step. In this manner formulae for the calculation of the fluctuations of the distribution function are found. Finally the formula found for the distribution of the scattered light to the angles and frequencies is explicitly written down. The frequency spectrum consists of a central part and of two sharp lines. The central part corresponds to the Doppler broadening of the main line. There are 9 references, 7 of which are Slavic.

ASSOCIATION: Institute for Physical Problems AN USSR (Institut fizicheskikh problem Akademii nauk SSSR)

SUBMITTED: July 30, 1957

AVAILABLE: Library of Congress

AUTHORS: Abrikosov, A. A., Gor'kov, L. P., ~~Khalatnikov, I. M.~~

SOV/56-35-1-37/59

TITLE: A Superconductor in a High-Frequency Field (Sverkhprovodnik v vysokochastotnom pole)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol. 35, Nr 1, pp. 265-275 (USSR)

ABSTRACT: Bardeen, Cooper and Schrieffer (Bardin, Kuper, Shriffer) developed a microscopical theory of superconductivity (Ref 1). In the present paper the question is investigated as to how superconductors behave in variable weak fields, and a new (not local) equation is derived, which describes the connection between current and field instead of the equation of the phenomenological theory by F. and G. London. Also the question of the depth of penetration of a weak static field into massive superconductors and their dependence on temperature is dealt with. In the present paper the authors investigate the behavior of superconductors in high-frequency fields and derive an equation describing this behavior. The paper is subdivided into 4 sections. The first deals with the setting-up of an equation for the current in superconductors $\vec{j}(\vec{k},\omega)$

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in dependence on $\vec{A}(x)$; section two deals with Pippard's limiting case, and section three deals with London's domain ($vk \ll \Delta$). In section four the temperature- and frequency dependence of the impedance of a massive superconductor is determined by means of the equation derived as mentioned above. Finally, the authors thank L. D. Landau, Academician, for the interest he displayed in their work.
There are 5 references, 1 of which is Soviet.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute of Physical Problems, AS USSR)

SUBMITTED: March 4, 1958

24(3), 24(5)

AUTHORS: Abrikosov, A. A., Dzyaloshinskiy, I. Ye. SOV/56-35-3-32/61

TITLE: ~~Spin Waves in a~~ Ferromagnetic Metal (Spinovyye volny v ferromagnitnom metalle)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol 35, Nr 3, pp 771-775 (USSR)

ABSTRACT: The first investigations of spin waves were carried out by Bloch (Blokh) (Ref 2) on the basis of Heisenberg's (Geyzenberg) model for ferromagnetics. The phenomenological theory was developed by Landau and Lifshits (Refs 3,4). In these theories the ferromagnetic substance is treated as a spin system which is firmly connected with the crystal lattice. However, this in no case applies to a metal in which the electrons are able to move freely. It is therefore of interest to find out in what form the motion of electrons can be represented in accordance with phenomenological theory. It is this problem that forms the object of the present paper; according to Landau (Ref 1) it is based upon the theory of the Fermi liquid. The electron spectrum of metals is described by means of quasiparticles which satisfy Fermi statistics. The energy

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of these quasiparticles depends on spinor orientation, and for the energy operator $\varepsilon(\vec{p},\sigma)$ it holds that

$\delta E = \frac{1}{2}\,Sp_\sigma \int \varepsilon(\vec{p},\sigma)\delta n(\vec{p},\sigma)d\tau$, $d\tau = 2dp_x dp_y dp_z/(2\pi\hbar)^3$, where $\vec{p}$ denotes the quasimomentum, $\vec{\sigma}$ - the spin operator, E - the energy of the unit of volume, n - the distribution function. For slight variations of n the following holds for the electron energy: $\delta\varepsilon(\vec{p},\vec{\sigma}) = \frac{1}{2}\,Sp_{\sigma'} \int f(\vec{p},\vec{\sigma};\vec{p}',\vec{\sigma}')\delta n(\vec{p}',\vec{\sigma}')d\tau'$, where $f(\vec{p},\vec{\sigma};\vec{p}',\vec{\sigma}') = \delta\varepsilon(\vec{p},\vec{\sigma})/\delta n(\vec{p}',\vec{\sigma}')$ and $f(\vec{p},\vec{\sigma};\vec{p}',\vec{\sigma}') = \psi(\vec{p},\vec{p}') + \psi(\vec{p},\vec{p}')(\vec{\sigma}\vec{\sigma}') + \psi_{ik}(\vec{p},\vec{p}')\sigma_i\sigma'_k$.

In ferromagnetic metals, in which only exchange-interaction occurs between the electrons, the energy operator depends only on the direction of spin with respect to the total magnetic moment: $\varepsilon(\vec{p},\vec{\sigma}) = \alpha(\vec{p}) - \beta(\vec{p}).\vec{m}\vec{\sigma}$ ($\vec{m}$ = unit-pseudovector in the direction of the magnetic moment of the crystal). For the equilibrium distribution function it holds that $n_o = \frac{1}{2}(n^+ + n^-) + \frac{1}{2}(n^+ - n^-)\vec{m}\vec{\sigma}$; $n^{\pm} = n_F(\alpha \mp \beta)$ (n_F = Fermi function). Further deliberations are based upon these equations. Expressions are

Spin Waves in a Ferromagnetic Metal

SOV/56-35-5-32/61

obtained for $\delta\varepsilon$, δn_0, and $\beta(p)$. Also non-ferromagnetic metals are discussed, in the case of which the terms with m do not occur and a law of dispersion of the form $\varepsilon \sim k$ applies (for ferromagnetic substances the law of dispersion $\varepsilon \sim k^2$ applies). Further, the connection between ω and k is investigated. Finally, the authors thank L. D. Landau, Academician, for his valuable advice and discussions of the results obtained. There are 6 references, 5 of which are Soviet.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute for Physical Problems, AS USSR)

SUBMITTED: April 22, 1958

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24(5), 24(6)

SOV/56-35-6-35/44

AUTHORS: Abrikosov, A. A., Gor'kov, L. P.

TITLE: On the Theory of Superconducting Alloys (K teorii sverkhprovodyashchikh splavov) 1. The Electrodynamics of Alloys at Absolute Zero (1. Elektrodinamika splavov pri absolyutnom nule)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol 35, Nr 6, pp 1558-1571 (USSR)

ABSTRACT: Bardeen, Cooper and Schrieffer (Bardin, Kuper, Shriffer) (Ref 1) developed an electrodynamics of superconductors and replaced the old phenomenological equation by G. and F. London by a new one, which describes the connection between the current $\vec{j}$ and the vector potential $\vec{A}$. The non-local form of the connection between current and field is based upon Cooper's conception (Ref 2) of the formation of coupled singlet pairs of electrons near the Fermi surface as a result of phonon interaction. The dimensions of these pairs correspond to the electron correlations in the case of distances of $\xi_0 \sim 10^{-4}$ if the penetration depth of the field $\ll \xi_0$ (non-local case, very pure superconductors). By means of these theories it is

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possible to develop thermodynamics and electrodynamics of superconductors, and it is possible to investigate their behavior in a high-frequency field (Ref 3). In this connection interest is caused by the so-called "alloys", i.e. superconductors with atomic impurities of other elements and with other lattice dislocations. In the case of very low concentrations, impurities play only a minor part. An increase of impurity concentration leads to a decrease of the spatial electron correlation in the superconductor. In the case of a suitable concentration, it is no longer ξ_0 that acts as a correlation parameter, but the free path of the electrons. In concentrations in which the length of path becomes small in comparision to penetration depth a local coupling between current and vector potential is to be expected. The difference to London's theory consists in the variation of the proportionality factor between $\vec{j}$ and $\vec{A}$. In the following, the authors investigate these questions on the assumption of small impurity concentrations. With detailed explanations and justifications of each individual step, equations are then derived, On the Theory of Superconducting Alloys. 1. The Electrodynamics of Alloys at Absolute Zero SOV/56-35-6-35/44

which describe the dependence of the penetration depth on the concentration of impurities, and also the electrodynamical equations in a varying field, this is done on the assumption that the electron free path for the superconductor is smaller than the correlation length. The authors in conclusion thank L. D. Landau, Academician, for his constant interest and valuable comments. There are 8 figures and 7 references, 5 of which are Soviet.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute for Physical Problems of the Academy of Sciences, USSR)

SUBMITTED: July 16, 1958

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AUTHORS: Abrikosov, A. A., Khalatnikov, I. SOV/53-65-4-2/13

TITLE: Modern Theory of Superconductivity (Sovremennaya teoriya sverkhprovodimosti)

PERIODICAL: Uspekhi fizicheskikh nauk, 1958, Vol 65, Nr 4, pp 551 - 591 (USSR)

ABSTRACT: In this paper a survey is given on the present state of the theory of superconductivity; aside from a short historical review the paper is restricted to later publications. Landau and Kapitsa were the first ones in the USSR to take up these problems, further N.N.Bogolyubov, V.Tolmachev, D.Shirkov ("New Methods in the Theory of Superconductivity"; lithographed edition of the Ob"yedinennyy institut yadernykh issledovaniy (United Institute of Nuclear Research)), L. Gor'kov, S.Tyablikov, N.Zavaritskiy, D.Shenberg and B.Geylikman. The papers by Landau and Bogolyubov are considered in particular. The authors treat in detail: The theory of the Cooper (Kuper) phenomenon, the ground state of superconductors, (the role of the Coulomb (Kulon) interaction of the electrons), thermodynamics in superconductors, (the measurement of the energy gap with temperature, the specific heat, the critical

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magnetic field, the number of the "normal" electrons), furthermore the electrodynamic equations for superconductors ($T = 0$ and $T \neq 0$, the depth of penetration, the diffusion dispersion, the properties of superconductors of finite dimensions), the behavior of superconductors in a periodic (high-frequency) field, (the Pippard critical case, the London domain, the impedance), and in the last section the heat conductivity of superconductors. There are 4 figures and 22 references, 14 of which are Soviet.

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AUTHORS: Abrikosov, A. A., Khalatnikov, I. M. SOV/53-66-2-3/9

TITLE: The Theory of the Fermi Liquid (the Properties of Liquid He^3 at Low Temperatures) (Teoriya Fermi-zhidkosti (svoystva zhidkogo He^3 pri nizkikh temperaturakh))

PERIODICAL: Uspekhi fizicheskikh nauk, 1958, Vol 66, Nr 2, pp 177-212 (USSR)

ABSTRACT: In 1956 L. D. Landau developed a systematic theory concerning the Fermi liquid (Ref 1). (It was also Landau who carried out the first quantum-theoretical investigation of the superfluidity of He II and who developed a theory of the Bose liquid). He also showed that, in contrast to what is the case in the Bose liquid, the interaction of excitation plays a very important part in the Fermi liquid. In the course of the present article the authors give a survey of the present stage of investigations of the properties of Fermi liquids on the basis of Landau's theory and by assuming the isotropy of the models investigated. Finally, the latest and final works by Landau are discussed (Refs 8, 12, 14, 21) in which it is shown in what way it is possible to

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derive the basic hypotheses of the theory of the Fermi liquid from a microscopical investigation of the interaction. Also the theory of the dissolved Fermi gas is taken into account. The following individual problems are dealt with in 10 paragraphs: 1) The excitation energy (ansatz for the energy of quasi-particles $\delta E = \int \varepsilon \, \delta n \, d\tau$ with $d\tau = 2dp_x dp_y dp_z/(2\pi h)^3$ (Factor 2 takes into account that spin $= 1/2$) and for the energy ε: $\varepsilon = \varepsilon_0(\vec{p},\vec{\sigma}) + \delta\, \varepsilon(\vec{p},\vec{\sigma})$). 2) The effective mass ($\varepsilon_0 - \mu(0) = v(p-p_0)$ $v = p_0/m^*$, where m^* denotes the effective mass). 3) Specific heat and entropy ($C = (\partial E/\partial T)_N$; $c = C/N = \gamma T$; $\gamma = (\pi/3N)^{2/3} \cdot \frac{m^*}{\hbar^2}$; $\gamma \sim 3$ cal/mol-degr.^{2}; $\varrho = 0{,}078$ g/cm^3; $m^* = 1{,}43\, m_{He^3}$; $\frac{p_0}{\hbar} = 0{,}76.10^8$ cm^{-1}). 4) Magnetic susceptibility; 5) The kinetic equation; 6) Viscosity ($\eta = \alpha/T^2$; $\alpha \sim 10^{-6}$ to 10^{-5} Poise,

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T in °K); 7) Thermal conductivity ($\varkappa = \frac{\beta}{T}$; $\beta \sim 10^2$ to 10^3 erg/cm.sec.degr.); 8) Sound (laws of the propagation of sound for $\omega\tau \ll 1$ and $\omega\tau \gg 1$); 9) Dispersion and the absorption of sound; 10) The propagation of light, fluctuations of the distribution function. In an appendix the authors discuss the microscopical theory of the Fermi liquid: Paragraph 1 deals with the dissolved Fermi gas and paragraph 2 with the microscopical theory of the Fermi liquid at T = 0. There are 3 figures and 21 references, 14 of which are Soviet.

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24(0) SOV/30-59-2-42/60

AUTHOR: Khalatnikov, I. M., Doctor of Physical and Mathematical Sciences

TITLE: Investigations of Low-temperature Physics (Issledovaniya po fizike nizkikh temperatur)

PERIODICAL: Vestnik Akademii nauk SSSR, 1959, Nr 2, pp 98-100 (USSR)

ABSTRACT: The 5th All-Union Conference on this problem took place in Tbilisi from October 27 to November 1, 1958. It was attended by physicists from Moscow, Khar'kov, Leningrad, Tbilisi, Sverdlovsk, and Kiyev. 4 fields of low-temperature physics were discussed: superliquidity of liquid helium II, supraconductivity, antiferromagnetism, magneto-resistive effect. The following reports and communications were heard: A. A. Abrikosov, L. P. Gor'kov reported on the investigation of the properties of supraconductive alloys. A. A. Abrikosov, L. P. Gor'kov, I. M. Khalatnikov spoke of properties of supraconductors in the high-frequency magnetic field. D. V. Shirkov and Chen' Chun'-yan' and Chzhou Si-shin', two young Chinese scientists working at Moscow University, described investigations for determination of the influence exercised by the Coulomb (Kulon) interaction of charges on supraconductivity. V. V. Tolmachev explained the

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nature of the so-called collective excitations of the Bose type in supraconductors. D. N. Zubarev, Yu. A. Tserkovnikov spoke of the thermodynamics of supraconductors and B. T. Geylikman, V. Z. Kresin of the thermal conduction of supraconductors. Yu. V. Sharvin, V. F. Gantmakher reported on experimental work with supraconductors. N. V. Zavaritskiy spoke of the measurement of the anisotropy of thermal conductivity in the supraconductive state. In a series of reports problems of the superliquidity of helium were discussed, which was discovered in 1938 by P. L. Kapitsa and the theory of which was set up in 1941 by L. D. Landau. E. L. Andronikashvili and his collaborators investigated the properties of rotating helium. V. P. Peshkov spoke of the effect of the formation of the boundary between superliquid and non superliquid helium. Guan Vey-yan', collaborator of the Institut fizicheskikh problem (Institute of Physical Problems) investigated the properties of the so-called jump in temperature of Kapitsa. I. M. Lifshits, V. D. Peschanskiy investigated galvanomagnetic phenomena in strong magnetic fields for metals with open Fermi surfaces. N. Ye. Alekseyevskiy, Yu. P. Gaydukov experimentally investigated the resistance anisotropy of gold monocrystals in the magnetic field. L. S. Kan, B. G. Lazarev combine the presence of a temperature minimum with the structural state of the metal. M. Ya. Azbel' reported on the quantum theory of metallic conductivity in the alternating electromagnetic and constant magnetic field. A. S. Borovik-Romanov reported on the weak ferromagnetism in antiferromagnetic samples of $MnCO_3$. N. M. Kreynes, Ye. A. Turov investigated the magnetic anisotropy of the antiferromagnetic monocrystals $CuSO_4$ and $CoSO_4$. R. A. Alikhanov reported on neutronographic investigations of antiferromagnetics. Ye. I. Kondorskiy and collaborators reported on the susceptibility of nickel and nickel-copper alloys at low temperatures. M. I. Kaganov, V. M. Tsukernik reported on kinetic phenomena in ferromagnetics at low temperatures. A. I. Akhiyezer, V. G. Bar'yakhtar, and S. P. Peletminskiy spoke of computations of the relaxation of the magnetic moment in ferromagnetic dielectrics at low temperatures. T. I. Sanadze spoke of observation results of paramagnetic resonance of terbium in the $TbNO_3 \cdot 6H_2O$ nitrate. G. R. Khutsishvili gave a theoretical analysis of the orientation of the nuclear spin in the Overhauser (Overkhauzer) effect in nonmetals. B. N. Samoylov, N. M. Reynov and collaborators reported on obtaining orientated nuclei. R. F. Bulatova, V. S. Kogan and B. G. Lazarev showed that hydrogen isotopes in solid state have different structures. I. A. Gindin, B. G. Lazarev, Kh. D. Starodubov and V. I. Khotkevich detected polymorphism in a number of metals at low temperatures. E. L. Andronikashvili, V. P. Peshkov and M. P. Malkov reported on the stage of development of foreign scientific research work in the field of low-temperature physics. At the end of the Conference P. L. Kapitsa spoke of his successful development of investigations in the field of low-temperature physics. The participants of the Conference visited the Institut fiziki Akademii nauk Gruzinskoy SSR (Physics Institute of the Academy of Sciences of the Gruzinskaya SSR) and the Physics Faculty of Tbilisi University as well as the building of the new research atomic reactor near Tbilisi.

ABRIKOSOV, A. A.

RUMANIA/Atomic and Nuclear Physics - Low Temperature Physics. D

Abs Jour : Ref Zhur Fizika, No 1, 1960, 870

Author : Abrikosov, A.A.

Inst : -

Title : The Problem of Superconductivity

Orig Pub : An. Rom.-Sov. Ser. mat.-fiz., 1959, 13, No 1, 37-64

Abstract : Translation from the journal Vestn. AN SSSR [Herald of the Academy of Sciences, USSR] 1958, No 4. See Referat Zhur Fizika, 1959, No 11, 25022.

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24(3)

AUTHORS: Abrikosov, A. A., Gor'kov, L. P.

SOV/56-36-1-48/62

TITLE: Superconducting Alloys at Temperatures Above Absolute Zero (Sverkhprovodyashchiye splavy pri temperaturakh vyshe absolyutnogo nulya)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 36, Nr 1, pp 319-320 (USSR)

ABSTRACT: In a previous paper the author developed the electrodynamics of superconductors containing impurities (in low atomic concentrations) at $T = 0$. However, this method cannot be applied to real temperatures. The authors and I. Ye. Dzyaloshinskiy developed a generalization of the method which can be applied to $T \neq 0$. They proceeded from a formulation of the thermodynamical theory which was suggested by T. Matsubara. These methods will be discussed in a separate paper. The principal functions for $T \neq 0$ are calculated in a similar manner as in the case $T = 0$. In the case of equilibrium, the entire modification consists practically in replacing the integrals over frequencies by sums over a discrete variable:

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$(1/2\pi)\int_{-\infty}^{\infty} d\omega f(\omega) \rightarrow (iT/\hbar) \sum_{n=-\infty}^{\infty} f(i\omega_n)$. It holds that $\omega_n = (\pi T/\hbar)(2n + 1)$, and T denotes the temperature in energy units. The authors used this method for the investigation of the equilibrium properties at finite temperatures. As in the case T = 0, the functions $G(x,x')$ and $F(x,x')$ (which were apparently defined in the above-mentioned previous paper) are simply multiplied by an exponential factor

$G(x,x') = G_0(x,x') \exp\left\{-|\vec{x}-\vec{x'}|/2l\right\}$

$F(x,x') = F_0(x,x') \exp\left\{-|\vec{x}-\vec{x'}|/2l\right\}$ where l denotes the free path length in the normal state. For the thermodynamic functions it is sufficient to determine the density of the particles as a function of the chemical potential and of the temperature

$N(\mu, T)$: $N = \langle\psi^{+}(x)\psi(x)\rangle = -i\left[G(x,x')\right]_{x=x';\ t=t'-0}$. The function $N(\mu,T)$ is the same as in the case of a pure superconductor. In the investigated model an introduction of admixtures does therefore not vary the thermodynamic functions (and, especially, critical temperature). This result naturally holds only in the case of low concentrations of the impurities. The authors also investigated the behavior of alloys in a constant magnetic field. A formula is given for the connection between the current and the vector potential in the London case, and therefrom a formula is deduced for the penetration depth. For great free-path lengths, this formula can be reduced to the usual expression for a pure London superconductor. The corresponding formula is given also for Pippard superconductors. All the formulae deduced in this paper for the penetration depth can be applied to the characteristics of films of a thickness $d \ll \delta$. In this case, δ does, however, not denote the depth of penetration, but it defines magnetic susceptibility and it figures in the expression for the effective dielectric constant at low frequencies. The author thanks Academician L. D. Landau for discussing this paper. There are 3 references, 1 of which is Soviet.

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ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute of Physical Problems of the Academy of Sciences, USSR)

SUBMITTED: July 16, 1958

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24(5)

SOV/56-36-3-39/71

AUTHORS: Abrikosov, A. A., Gor'kov, L. P., Dzyaloshinskiy, I. Ye.

TITLE: On the Application of the Methods of the Quantum Field Theory to Problems of Quantum Statistics at Finite Temperatures (O primenenii metodov kvantovoy teorii polya k zadacham kvantovoy statistiki pri konechnykh temperaturakh)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 36, Nr 3, pp 900-908 (USSR)

ABSTRACT: The present paper intends to formulate a variation of the thermodynamic perturbation theory which permits the full application of quantum-field theoretical methods to quantum statistics at finite temperatures. This method is in principle based on an extension of the method developed by Matsubara (Ref 4). In the Green's functions transition to "imaginary times" is made by $t \rightarrow -i\tau\hbar$, and from operators of second quantization in Schroedinger (Shredinger) representation $\tilde{\psi}, \tilde{\psi}^+$ transition is made to operators in "interaction representation" $\psi(\vec{r},\tau)$, $\psi^+(\vec{r},\tau)$; these new Green's functions are expanded according to the imaginary time variable in Fourier series.

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On the Application of the Methods of the Quantum Field Theory to Problems of Quantum Statistics at Finite Temperatures

This procedure differs from the usual one by the fact that integration with respect to frequencies is replaced by summation over discrete values of the imaginary "frequency" $i\omega_n$; otherwise this method is fully equivalent to the usual diagram-technique in the momentum space at $T = 0$. In the following, the analytical properties of the Fourier (Fur'ye) components of the Green's functions are investigated and it is shown that, due to the possibility of analytical continuation, it suffices for the treatment of various kinetic and non-steady problems to know the corresponding equilibrium Green's functions. The authors finally thank Academician L. D. Landau and L. P. Pitayevskiy for discussing the results obtained by this paper. There are 4 figures and 9 references, 5 of which are Soviet.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute for Physical Problems of the Academy of Sciences, USSR)

SUBMITTED: December 4, 1958

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24 (3)

AUTHORS: Abrikosov, A. A., Gor'kov, L. P., ~~Khalatnikov~~, I. M. SOV/56-37-1-29/64

TITLE: The Analysis of Experimental Data on the Surface Impedance of Superconductors (Analiz eksperimental'nykh dannykh o poverkhnostnom impedanse sverkhprovodnikov)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 37, Nr 1(7), pp 187 - 191 (USSR)

ABSTRACT: The authors compare the experimental data on the measurement of the surface impedance of superconductors for different frequencies with the conclusions drawn from the new theory of superconductivity. The properties of superconductors in a high-frequency field were investigated in a previous paper of the authors (Ref 1) and in a paper by D. C. Mattis and J. Bardeen (Ref 2). The present paper compares the theory with the experimental data on the surface impedance of superconductors. The authors give, above all, formulas for the surface impedance in various limiting cases which are suitable for a convenient comparison with the experiment. The amount usually measured by experiment, of the ratio between the impedance $Z(\omega)$ in supercon-

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ductive state and the real part of the impedance in the normal state is given by the formula $Z(\omega)/R_n = -2i(\pi\omega/\Delta Q(\omega))^{1/2}$ in Pippard's limiting case. An expression for the complex function $Q(\omega)$ is then written down, and an expression for the frequency dependence of the impedance follows subsequently. Now the authors analyze the temperature dependence for various frequencies at temperatures different from zero. The following cases are investigated in detail (the quantity 2Δ denoting the gap, in the energy spectrum at a given temperature): (a) $\omega \ll \Delta(0)$, (b) $\omega \sim \Delta(0)$: This very case is the most difficult one for comparing theory with experiment, for the quantities Δ, ω and T are, over a large part of the temperature interval $0 < T < T_c$, of the same order of magnitude. The expression for $Q(\omega)$ can only be simplified in the range of low temperatures $T \ll \omega \sim \Delta$. (c) $\omega \gg \Delta(0)$. In this case, only the ratio between T and Δ changes, and ω is always large with respect to these two quantities. The formulas written down in the present paper permit a detailed comparison of theory with numerous experimental data.

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In the range of very high frequencies $\omega \gg$, no experimental data have become known up to date. The causes of disagreement between the experimental data and the values of impedance calculated by the new theory of superconductivity have not yet been clarified. There are 3 figures and 6 references, 3 of which are Soviet.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute of Physical Problems of the Academy of Sciences, USSR)

SUBMITTED: February 3, 1959

Card 3/3

A.A. Abrikosov

24(0) SOV/53-67-4-7/7

AUTHOR: Chentsov, R.

TITLE: The Fifth All-Union Conference on the Physics of Low Temperatures (5-ye Vsesoyuznoye soveshchaniye po fizike nizkikh temperatur)

PERIODICAL: Uspekhi fizicheskikh nauk, 1959, Vol 67, Nr 4, pp 745-750 (USSR)

ABSTRACT: This Conference took place from October 27 to November 1 at Tbilisi; it was organized by the Otdeleniye fiziko-matematicheskikh nauk Akademii nauk SSSR (Department of Physico-mathematical Sciences of the Academy of Sciences, USSR), the Akademiya nauk Gruzinskoy SSR (Academy of Sciences, Gruzinskaya SSR), and the Tbilisskiy gosudarstvennyy universitet im. Stalina (Tbilisi State University imeni Stalin). The Conference was attended by about 300 specialists from Tbilisi, Moscow, Khar'kov, Kiyev, Leningrad, Sverdlovsk, and other cities as well as by a number of young Chinese scientists at present working in the USSR. About 50 lectures were delivered which were divided according to research fields.

II. Supraconductivity. 15 lectures were delivered on this field of which two were experimental and the others theoretical. Reports on experimental investigations of supraconductivity were delivered by Yu. V. Sharvin and V. F. Gantmakher (IFP) and N. V. Zavaritskiy (IFP). The former investigated the structure of the intermediate state in monocrystals of pure tin, the latter measured the thermal conductivity of differently shaped orientated cylindrical gallium samples at 0.1 - 4.2°K. A. A. Abrikosov, L. P. Gor'kov and I. M. Khalatnikov (IFP) theoretically investigated the behavior of a superconductor in the high-frequency field. V. L. Ginzburg and G. F. Zharkov (FIAN) dealt with the microscopical theory, and Ginzburg discussed among other things the part played by fluctuations in phase transitions of the second kind. I. M. Lifshits (KhFTI) showed that it follows from the modern theory of supraconductivity in consideration of the anisotropy of metals that, in principle, the existence of supraconductors is possible which are supra-conductive only within a limited range of temperature (and not at all temperatures below the critical ones). B. T. Geylikman and V. Z. Kresin (IAE) investigated the electron- and phonon thermal conductivity of supraconductors by means of the microscopical theory at temperatures that are not very near absolute zero. M. V. Buykov and L. E. Gurevich (FTI AN SSSR) spoke about the surface energy on the boundary between the supraconductive and normal phases. D. N. Zubarev and Yu. A Tserkovnikov (Matematicheskiy institut AN SSSR - Mathematics Institute AS USSR) dealt with the thermodynamics of the supraconductive state (Froehlich-model). V. V. Tolmachev (FIAN) investigated the problem of collective excitations in a supraconductor. D. V. Shirkov (Ob"yedinennyy institut yadernykh issledovaniy - Joint Institute of Nuclear Research) spoke about consideration of Coulomb-interaction of electrons in semiconductors. The problem of consideration of the Coulomb interaction was discussed by Chen' Ch'un-hsien and Chou, Hsi-hsin (PCU).

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AUTHORS: Abrikosov, A. A., Gor'kov, L. P.

TITLE: The Problem of Knight Shift in Superconductors

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 2(8), pp. 480 - 483

TEXT: A number of scientists have interested themselves in the theory of Knight shift in semiconductors (displacement of the nuclear resonance frequency as compared with that of dielectrics). The purpose of the present paper was to explain the experimental data. The Knight shift is due to the paramagnetism of the conduction electrons. Since the electron wave function is anomalously large in the neighbourhood of the nucleus, the magnetization of the electrons causes a change in the magnetic field acting upon the nucleus; the deviation of the effective field from the external one is given by $\Delta H = (8\pi/3N_{at})|\psi(0)|^2\chi H$, where $|\psi(0)|^2$ is the probability density of the electron at the position of the nucleus, N_{at}

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is the number of atoms per unit volume, χ is the electronic susceptibility, and H is the external field. The authors first discuss the results and methods of other related works, and show that a homogeneous field can exist only in such semiconductors whose dimensions are very small compared to the depth of penetration, δ, of the static field. (The experimental work was done with an emulsion of a semiconductor). A consideration of massive semiconductor in a homogeneous field (e.g. Ref. 1) corresponds to no practical situations. Also, the results obtained by other authors (Refs. 3,4) relating to the effect of impurities are criticized and the errors indicated. The authors of the present work have elaborated in earlier publications a method for the theoretical investigation of semiconductors with impurities. Here an expression for the spin magnetic moment of the electron system in a homogeneous magnetic field is first written down and transformed. The impurities are taken into account in a manner completely analogous to Refs. 7 and 8. The experiments show, in particular, that for T = 0 the susceptibility χ vanishes and therefore there can be no Knight shift. (The authors of Refs. 3,4 found the opposite result; also experimentally χ was not found to be zero for T = 0). In this connection, the authors also comment on

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the interpretation of the experiment of Reif (Ref. 5). For low temperatures, the field was no more homogeneous, as is also indicated by the large width of the resonance line. A discussion is also given of the characteristics of transition from the supraconducting to normal state for particles which are smaller than the depth of penetration of the field. The authors finally thank Academician L. D. Landau for discussions. There are 9 references: 3 Soviet and 6 US.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute of Physical Problems of the Academy of Sciences of the USSR)

SUBMITTED: March 23, 1960

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24.2140 (1072,1158,1160)

AUTHORS: Abrikosov, A. A., Gor'kov, L. P.

TITLE: Theory of Superconductive Alloys With Paramagnetic Impurities

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 6(12), pp. 1781-1796

TEXT: Experiments on the effect of paramagnetic impurities upon the critical temperature of superconductors have shown that an admixture of such elements leads to a decrease of T_c, whereas an admixture of ferromagnetic elements (e.g., to titanium - Ref. 4) results in an increase of T_c. A study of this phenomenon has been made on the basis of a microscopic theory of superconductivity. The mechanism of superconductivity is related to the formation of bound electron pairs in the singlet state. Exchange interaction between electrons and spinning impurity atoms leads to non-conservation of the electron spin, which indicates the formation of Cooper pairs. Thus, the spin of the impurity atoms is likely to complicate

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the occurrence of superconductivity and causes a decrease in T_c. This assumption was confirmed by a theoretical study described here. It is assumed that the interaction of an electron with an impurity atom is described by an expression in which the exchange term $\hat{v}(\vec{r}) = u_1(\vec{r}) + u_2(\vec{r})(\vec{S}\vec{\sigma})$ is contained; $\vec{S}$ is the momentum of the impurity atom, and $\hat{\sigma}$ is the electron spin matrix. The Hamiltonian describing the interaction between electrons and impurity atoms is assumed to be given by $H_{int} = (\psi^+\hat{V}\psi) = (\psi^+\sum_a \hat{v}(\vec{r} - \vec{r}_a)\psi)$ (second-quantization representation). First, the dependence of the transition temperature T_c on the impurity concentration is described. Following a previous paper, the superconductor is described by two Green functions. When the impurity concentration is small ($\varrho \ll 1$), the critical temperature drops in proportion to the impurity concentration: $T_c = T_{co} - \pi/4\tau_s$. If $\varrho \gg 1$, i.e., $T_c/T_{co} \ll 1$, then $T_c^2 = (6/\pi^2\tau_s^2)\ln(\pi T_{co}\tau_s/2\gamma)$. At a certain critical concentration of the

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paramagnetic impurities, which is determined by the condition $\tau_{s\,cr} = 2\gamma/\pi T_{co}$ there is no superconductivity any longer throughout the temperature range. The critical path is given by $l_{s\,cr} = v\tau_{s\,cr} \sim 10^{-4}$ cm. In addition, the thermodynamic and electromagnetic properties of alloys within the range of critical concentration have been studied, i.e. at $\tau_s \approx \tau_{s\,cr}$. It is noted that the expression for the ratio between the specific heats of the superconductive and the normal phase contains no exponential term at $T \to 0$. This means that there is not gap in the spectrum of these superconductors and, consequently, no absorption threshold for electron magnetic radiation at $T = 0$. Finally, the dependence of the spectrum gap at $T = 0$ on the impurity concentration is described. The gap disappears at a concentration that is somewhat lower than the critical one ($n' = 2e^{-\pi/4} n_{cr} \approx 0.91\ n_{cr}$), and the spectrum remains continuous at higher concentrations. L. D. Landau is thanked for discussions. N.N. Bogolyubov, V. L. Ginzburg, A. B. Migdal, V. M. Galitskiy, and A. I. Shal'nikov are mentioned. There are 4 figures and 17 references: 9 Soviet and 8 US.

Card 3/3 Inst. Physical Problems AS USSR

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88461

S/056/60/039/006/053/063
B006/B063

24.4100

AUTHOR: Abrikosov, A. A.

TITLE: Some Properties of Heavily Compressed Matter. I

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 6(12), pp. 1797-1805

TEXT: The purpose of the present work was to calculate the energy of the ground state of highly compressed matter. The energy of the ground state of a highly compressed electron gas has been calculated by Gell-Mann, Brueckner and Sawada (Refs. 1-3); the model, however, they used for the purpose differed considerably from real matter: homogeneously distributed positive charge was assumed instead of ions. This model is not very useful, especially if the ions form a lattice. In addition, it gives an incorrect representation of the real conditions for liquids. The author has studied the properties of highly compressed single-component matter at $T = 0$ proceeding from the assumption that the nuclei form a crystal lattice. In addition, ν is supposed to be much greater than 1, i.e. the electrons may be considered non-relativistic particles. First, the binding energy of the

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crystal and the electron exchange energy are calculated. These energies are given by $E^{(1)} = v^{-1/3}(0.74Z^{4/3} + 1.3\ Z^2)$. Thus, it is possible to give a more exact defi ition of the criterion for the applicability of the non-relativistic approximation: $v^{1/3} \ll 2Z^{-1/3}$ for pressures higher than 10^8 atm. In the following, the moduli of elasticity are studied. The following relation is immediately obtained for the volume compressi ility which is determined primarily by electrons: $K = \frac{\pi^{4/3}\hbar^2}{3^{1/3}m}\left(\frac{ZN}{V}\right)^{5/3}$. More extensive calculations are required for the determination of the shear modulus which is determined by the nuclear Coulomb interaction. In addition, the vibrational spectrum has been studied. In this case, the great difference between compression and shear moduli is particularly marked. Next, the possible destruction of the lattice under heavy compression is dealt with. From the shape obtained for the lattice vibration spectrum, $E_v \sim Z\sqrt{m/M}\ v^{-1/2}$ follows for the zero-vibration energy; when the volumes are sufficiently small, this positive energy may exceed the (negative) Coulomb energy and thus lead to the destruction of the

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Some Properties of Heavily Compressed Matter. I S/056/60/039/006/053/063
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lattice. A detailed study shows that relativistic effects may appear already with specific volumes in the order of $10^{-6}Z^{-6}A^{-3}$. It has been shown that such a transition can exist only for hydrogen and helium. Finally, the second-order corrections to the energy of the ground state are calculated, and an expression is given for the electron-ion correlation energy. For the electron-electron correlation energy one obtains $E^{(2)}_{ee} = Z\left[0.0104\ \ln(v/Z) - 0.1108\right]$. All formulas presented in this article refer to cubic lattices. Academician L. D. Landau is thanked for discussions. There are 7 references: 4 Soviet and 3 US.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute of Physical Problems, Academy of Sciences USSR)

SUBMITTED: July 26, 1960

Card 3/3

89220

24.2140 (1072,1160,1395)

S/056/61/040/001/026/037
B102/B212

AUTHORS: Abrikosov, A. A., Fal'kovskiy, L. A.

TITLE: Raman scattering of light in superconductors

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 1, 1961, 262-270

TEXT: A study of the behavior of a superconductor allows many conclusions as to its energy spectrum. The existence of a gap Δ in the energy spectrum brings about an effect that at T=0 a radiation with a frequency smaller than the threshold frequency 2Δ is not absorbed. Besides such experiments with varied frequencies, M. S. Khaykin and V. P. Bykov have carried out other experiments in order to determine the electron spectrum with the help of Raman scattering of light in superconductors. At a sufficiently high intensity, it should be possible to measure the distribution of satellite frequencies spectroscopically. The main problem of such experiments is that scattering is extremely small in connection with the fact that due to the skin effect the light will only penetrate about 10^{-5} cm into a body. No satellite lines have been observed by Khaykin and Bykov; now the ques-

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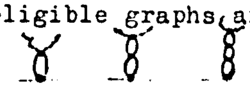
tion comes up, how much the sensitivity has to be increased in order to perform such an experiment successfully and how would such an effect look like. To find out this was the aim of the present work. The authors tried to determine the frequency and angular distribution of a plane surface of a superconductor, filling a semispace z>0 at T=0. For simplicity the incident and reflected waves were assumed to form only small angles with the surface normal ($\sin^2\theta$, $\sin^2\theta' \ll |\varepsilon|$; ε denotes the complex dielectric constant). For most metals $|\varepsilon|\sim 10$. Furthermore, the radiation frequency was assumed to fall in the optical region. Since the absorption probability of a quantum is $B^{-}(\omega'\Omega') = \sum_j |S_{j0}|^2$, it is possible to concentrate the problem to determining the elements S_{j0} of the scattering matrix, which describe the transition from the ground state to the j-th state for electrons of the outer field A_2+A_2'. (The incident wave produces a field in the metal which is characterized by the vector potential A_2). The elements of the S-matrix are determined by a method using quantum field theory, as outlined by L. P. Gor'kov (also A. A. Abrikosov and Gor'kov, Ref. 4). Several eligible graphs are examined, and it is found that only graphs of the type  are of interest. This expression is found for

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the corresponding matrix element: $S_{10} = -i\int\langle j|(e^2/m)(\vec{A}_2(x)\vec{A}'_2(x))\Psi^+_\alpha(x)\Psi_\alpha(x)|0\rangle d^4x$, and the total probability for all possible processes is given by

$$\sum_j |S_{j0}|^2 = \frac{e^4}{m^2}\int (A^*_2(x')A'_2(x'))(A_2(x)A'_2(x)) \times$$
$$\times \langle\psi^+_\alpha(x')\psi_\alpha(x')\psi^+_\beta(x)\psi_\beta(x)\rangle d^4x d^4x'. \quad (2)$$

For an infinite superconductor relation

$$\begin{aligned}
\langle\psi^+_\alpha(x')\psi_\beta(x)\rangle &= \delta_{\alpha\beta}\int v_p^2\delta(\varepsilon+\varepsilon_p)e^{ip(x-x')}\frac{d^4p}{(2\pi)^4},\\
\langle\psi_\alpha(x')\psi^+_\beta(x)\rangle &= \delta_{\alpha\beta}\int u_p^2\delta(\varepsilon-\varepsilon_p)e^{ip(x'-x)}\frac{d^4p}{(2\pi)^4},\\
\langle\psi_\alpha(x')\psi_\beta(x)\rangle &= -I_{\alpha\beta}\int u_p v_p\delta(\varepsilon-\varepsilon_p)e^{ip(x'-x)}\frac{d^4p}{(2\pi)^4},\\
\langle\psi^+_\alpha(x')\psi^+_\beta(x)\rangle &= I_{\alpha\beta}\int u_p v_p\delta(\varepsilon+\varepsilon_p)e^{ip(x-x')}\frac{d^4p}{(2\pi)^4}.
\end{aligned} \quad (3)$$

$$p = (\varepsilon, \mathbf{p}), \qquad \varepsilon_p = \sqrt{\xi_p^2+\Delta^2}, \qquad \xi_p = v(|\mathbf{p}|-p_0),$$
$$u_p^2 = \tfrac{1}{2}(1+\xi_p/\varepsilon_p), \quad v_p^2 = \tfrac{1}{2}(1-\xi_p/\varepsilon_p);$$

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holds; $I_{\alpha\beta}$ is an antisymmetric two-row unit matrix. The following expression is then obtained: $\sum_J |S_{J0}|^2 = \frac{e^4}{2m^2} t \mathfrak{S} \int R(q_z) f(\vec{q}) dq_z$ ($\mathfrak{S}$ - surface area);

and after some intermediate calculations one finds:

$f(\vec{q}) = \frac{p_o^2}{\pi^2 v^2 |\vec{q}|} \left[\left(\frac{q_o}{2} + \Delta\right) E\left(\frac{q_o - 2\Delta}{q_o + 2\Delta}\right) - \frac{q_o \Delta}{q_o/2 + \Delta} K\left(\frac{q_o - 2\Delta}{q_o + 2\Delta}\right)\right]$, where E and K are the complete elliptic integrals, and

$$R(q_z) = 8|A_0|^2 |A_0'|^2 \cos^2\theta \cos^2\theta' \left\{ \frac{\cos^2\varphi}{[(n+\cos\theta)^2 + \varkappa^2][(n+\cos\theta')^2 + \varkappa^2]} + \frac{\sin^2\varphi}{[(n\cos\theta+1)^2 + \varkappa^2\cos^2\theta][(n+\cos\theta')^2 + \varkappa^2]} + \frac{\sin^2\varphi}{[(n+\cos\theta)^2 + \varkappa^2][(n\cos\theta'+1)^2 + \varkappa^2\cos^2\theta']} + \frac{\cos^2\varphi}{[(n\cos\theta+1)^2 + \varkappa^2\cos^2\theta][(n\cos\theta'+1)^2 + \varkappa^2\cos^2\theta']} \right\} \frac{16\varkappa^2\omega^2}{(q_z^2 + 4\varkappa^2\omega^2)^2}. \quad (10)$$

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Raman scattering of ... S/056/61/040/001/026/037
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The reflection coefficient $d\sigma$, which is defined as the fraction of energy hitting the superconductor surface that is reflected in the angular interval $d\Omega'$ and in the frequency interval $d\omega'$ is obtained as

$$d\sigma = \frac{2e^4}{\pi^3}\,\frac{\cos\theta\cos^2\theta'}{\varkappa^2\omega^2}\Big\{[(1+\cos^2\theta)(n^2+\varkappa^2+1)+4n\cos\theta]\times$$
$$\times[(1+\cos^2\theta')(n^2+\varkappa^2+1)+4n\cos\theta']+\sin^2\theta\sin^2\theta'\cos 2\varphi\,(n^2+\varkappa^2-1)^2\Big\}\times$$
$$\times\{[(n\cos\theta+1)^2+\varkappa^2\cos^2\theta][(n\cos\theta'+1)^2+\varkappa^2\cos^2\theta'][(n+\cos\theta)^2+\varkappa^2]\times$$
$$\times[(n+\cos\theta')^2+\varkappa^2]\}^{-1}\Big[\left(\frac{\omega-\omega'}{2}+\Delta\right)E\left(\frac{\omega-\omega'-2\Delta}{\omega-\omega'+2\Delta}\right)-$$
$$-\frac{2(\omega-\omega')\Delta}{\omega-\omega'+2\Delta}K\left(\frac{\omega-\omega'-2\Delta}{\omega-\omega'+2\Delta}\right)\Big]\ln\frac{2\varkappa\omega v}{\omega-\omega'}\,d\omega' d\Omega. \qquad (11)$$

The numerical value for Nb is at $\lambda\sim 5800$ A ($\omega = 3.2\cdot 10^{15}\,\mathrm{sec}^{-1}$), $\theta=\theta'=0$,: $d\sigma = 0.6\cdot 10^{-12}\beta\, d\Omega d\omega'/2\Delta$; $\beta\sim 1$. It was thus found that in order to be able to observe such an effect, the sensitivity has to be at least 10^5 times higher than in experiments of Khaykin and Bykov. Finally, the authors thank Academician L. D. Landau and M. S. Khaykin for discussions. There are 6 figures and 5 references: 4 Soviet-bloc.

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Inst. Physical Problems AS USSR

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S/056/61/041/002/023/028
B125/B138

AUTHOR: Abrikosov, A. A.

TITLE: Theory of heavily compressed matter. II

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 41, no. 2(8), 1961, 569-582

TEXT: This article deals with the interaction of electrons and ions in heavily compressed matter and with the possibility of superconductivity. In order to determine the excitation spectrum in an isotropic system, one must find the poles of the Fourier form of the corresponding Green function $G_{\alpha\beta}(\vec{x}-\vec{x}';\ t-t') = -i\langle T(\tilde{\psi}_\alpha(\vec{x},t)\tilde{\psi}^+_\beta(\vec{x}',t'))\rangle$ (1.1), where $\tilde{\psi}_\alpha$ are the Heisenberg operators, and $\langle\ldots\rangle$ denotes averaging through ground state. The Fourier components of G for $t-t'$ read

$$G(\varepsilon;\mathrm{x},\mathrm{x}') = \frac{1}{V}\sum_{\mathrm{k},n} e^{i\mathrm{k}(\mathrm{x}-\mathrm{x}')}\left\{\frac{u_{n\mathrm{k}}(\mathrm{x})\,u^{*}_{n\mathrm{k}}(\mathrm{x}')}{\varepsilon-\xi_n(\mathrm{k})+i\delta}+\frac{v_{n\mathrm{k}}(\mathrm{x})\,v^{*}_{n\mathrm{k}}(\mathrm{x}')}{\varepsilon+\xi_n(\mathrm{k})-i\delta}\right\}, \quad (1,4)$$

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where $\xi_n(\vec{k}) = E_{n\vec{k}} - E_o$. Furthermore, one finds

$$G(\varepsilon; k + K, k' + K') = G(\varepsilon; K, K'; k)(2\pi)^3 \delta(k - k'),$$

$$G(\varepsilon; K, K'; k) = \sum_n \left\{ \frac{u_{nk}(K) u^*_{nk}(K')}{\varepsilon - \xi_n(k) + i\delta} + \frac{v_{nk}(K) v^*_{nk}(K')}{\varepsilon + \xi_n(k) - i\delta} \right\}. \qquad (1.7)$$

After that the electron excitation spectrum, as in the case of an isotropic Fermi system, is determined from the poles of the Green function, which do not depend on $\vec{K}$ and $\vec{K}'$. For the sake of simplicity, the author investigates only the electron spectrum of compressed hydrogen. In this case, the correction to the "intrinsic energy term" for the field of the static lattice will only be of the second order of magnitude. The vertex corresponding to the Coulomb electron interaction reads $\Gamma_{01} = 4\pi e^2/\vec{k}^2$. The electron-phonon vertex depends on the number of operators of the phonon field. The simplest graph for the Γ due to electron-phonon interaction has the form $\rangle$----$\langle$ and is described by

$$\Gamma_{02}(\varepsilon_p, p; \varepsilon_q + \omega, q + k + K; \varepsilon_p + \omega, p + k + K'; \varepsilon_q, q) =$$
$$= 4\pi e^2 \omega_0^2 D_{\alpha\beta}(\omega, k)(k + K)_\alpha (k + K')_\beta / (k + K)^2 (k + K')^2, \qquad (2.2)$$

where $\omega_o = \sqrt{4\pi e^2 N/MV}$, and $D_{\alpha\beta}(\omega,\vec{k})$ is the Fourier component of the Green function of the phonons. The author considers only the case $\vec{K} = \vec{K}' = 0$, $k \ll p_o$. Debye screening is allowed for by the summation of certain loops in the graph. After summation of all graphs one finds

$$\Gamma(\vec{k},\omega) = \frac{4\pi e^2 \omega^2}{(\omega^2 - \omega_o^2)k^2 + 4\pi e^2 \Pi \omega^2 + i\delta} \qquad (2.11),$$

from which the following limiting cases result:

$$\Gamma(\omega \ll uk) = \frac{4\pi e^2 \omega^2}{\omega^2(k^2 + \varkappa^2) - \omega_o^2 k^2 + i\delta} \qquad (2.12).$$

For $k \to 0$ one obtains $\Gamma \to 4\pi e^2/\varkappa^2$ if $uk \gg \omega \gg c_1 k$, and $\Gamma \to 4\pi e^2 \omega^2/\omega_o^2 k^2$ if $\omega \ll c_1 k$.

$$\Gamma_\omega \equiv \Gamma(\omega \gg uk) = \frac{4\pi e^2 \omega^2}{k^2(\omega^2 - 4\pi e^2 N/mV + i\delta)} \qquad (2.14)$$

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is approximately valid for $\omega \gg uk$. The pole in Γ_{∞} for $\omega_p = \sqrt{4\pi e^2 N/mV}$ corresponds to the plasma oscillations. Finally, one obtains

$$\Gamma \rightarrow -mV\omega^2/Nk^2, \quad \omega_p \gg \omega \gg uk \qquad (2.16).$$

If superconductivity does exist the order of magnitude of half the binding energy of a pair is given by $\Delta \sim \omega_0 \exp(-\pi u/e^2)$. Superconductivity is therefore an exponentially small effect, and the width of the gap will decrease during compression. The tedious calculation of the electron spectrum leads to the following results: The author determines all the terms constituting the energy part of Σ. The pole of the G function is obtained by solving the equation $\varepsilon - \xi + \Delta\mu - \Sigma = 0$, i.e., $\varepsilon = \xi + \Sigma(\varepsilon = \xi) - \Delta\mu$. The real and the imaginary part of the pole of the G function are known to determine the energy of excitations and their attenuation $\varepsilon(p) = \xi(p) + \mathrm{Re}\,\Sigma + \Delta\mu$, $\gamma = \mathrm{Im}\,\Sigma$. Summarizing all individual results, one obtains

$$\varepsilon(p) = \begin{cases} \xi(p)(1 + e^2\alpha_1/\pi u), & \xi \ll \omega_0 \\ \xi(p)[1 + (e^2/\pi u)(\ln(2p_0/\varkappa) - 1)], & \omega_0 \ll \xi \ll \varkappa u \\ \xi(p)[1 + (e^2/\pi u)\ln(2p_0 u/\xi(p))], & \varkappa u \ll \xi \ll u p_0 \\ \xi(p)[1 + (e^2 m/\pi p)\ln((p + p_0)/|p - p_0|)], & \xi \sim u p_0 \end{cases} \quad (4.19)$$

and

$$\gamma = \frac{e^2}{u} \cdot \begin{cases} \xi^2/6\omega_0^2, & \xi \ll \omega_0 \\ {}^1/_{16}\,\pi\xi|\xi|/u\varkappa + \omega_0 \operatorname{sign}\xi\,[{}^1/_2 \ln(p_0/\varkappa) + \alpha_2], & \omega_0 \ll \xi \ll u\varkappa. \\ {}^1/_2\,\beta_2 u\varkappa \operatorname{sign}\xi, & \xi \gg \varkappa u \end{cases} \quad (4.20)$$

The constants α_1 and α_2 depend on the parameters of the short-wave region of the photon spectrum, and the constants β_1 and β_2 are expressed by the integral

$$\beta_1 + i\beta_2 = \int_0^1 dz \left(1 - z \operatorname{th} z + \frac{i\pi}{2} z\right)^{1/2} \qquad (4.12).$$

In the range $\omega_0 \ll \xi \ll u\varkappa$, the change of the "velocity on the Fermi surface", given by (4.19), corresponds to Gell-Mann's formula for the specific heat due to electrons (Phys. Rev., 106, 369, 1957). Academician L. D. Landau

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Theory of heavily compressed...

S/056/61/041/002/023/028
B125/B138

is thanked for a discussion. There are 6 figures and 7 references: 4 Soviet and 3 non-Soviet. The two references to English-language publications read as follows: L. Cooper. Phys. Rev., 104, 1189, 1957; M. Gell-Mann. Phys. Rev., 106, 369, 1957.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute of Physical Problems of the Academy of Sciences USSR)

SUBMITTED: March 13, 1961

Card 6/6

ABRISKOV, Aleksey Alekseyevich; GOR'KOV, Lev Petrovich; DZYALOSHINSKIY, Igor' Yekhiyel'yevich; GUROV, K.P., red.; PLAKSHE, L.Yu., tekhn. red.

["Quantum field theory methods in statistical physics] Metody kvantovoi teorii polia v statisticheskoi fizike. Moskva, Fizmatgiz, 1962. 443 p. (MIRA 15:7)

(Quantum field theory)

ABRIKOSOV, A.A., doktor fiziko-matematicheskikh nauk; KHALATNIKOV, I.M., doktor fiziko-matematicheskikh nauk, prof. (Moskva)

Academician Lev Davidovich Landau. Fiz.v shkole 22 no.1:21-27 Ja-F '62. (MIRA 15:3)

(Landau, Lev Davidovich, 1908-)

ABRIKOSOV, A.A., doktor fiziko-matematicheskikh nauk, prof.; KHALATNIKOV, I.M., doktor fiziko-matematicheskikh nauk, prof. (Moskva)

Symmetry of the world. Fiz. v shkole 22 no.5:4-13 S-O '62. (MIRA 15:12)

(Particles (Nuclear physics)) (Symmetry)

TAMM, I.Ye., akademik; ABRIKOSOV, A.A., doktor fiz.-matem.nauk; KHALATNIKOV, I.M., doktor fiz.-matem.nauk

Nobel prize winner for 1962. Vest.AN SSSR 32 no.12:63-67 D '62. (MIRA 15:12)

(Landau, Lev Davidovich, 1908-)

37...

S/056/62/042/004/027/037
B108/B102

24.2140

AUTHORS: Abrikosov, A. A., Gor'kov, L. P.

TITLE: Spin-orbit interaction and the Knight shift in superconductors

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 42, no. 4, 1962, 1088 - 1096

TEXT: It is shown that consideration of spin-orbit interaction may provide a quantitative explanation of the frequency shift of nuclear magnetic resonance in superconductors at absolute zero. This Knight shift is proportional to the paramagnetic susceptibility of the conduction electrons. In a polycrystalline small superconductor the electrons undergo scattering from the grain boundaries. Owing to spin-orbit interaction, scattering changes the paramagnetic susceptibility of the superconductor, thereby leading to the Knight shift. Formulas of the type

$$\frac{\chi_s}{\chi_n} = 1 - \Delta^2 \pi T \sum_{\omega=-\infty}^{\infty}{}' \frac{1}{(\omega^2 + \Delta^2)\left[\sqrt{\omega^2 + \Delta^2} + 2/3\tau_1\right]} \qquad (18)$$

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are obtained for the paramagnetic susceptibilities. Δ is the energy gap in the spectrum of the pure superconductor at a given temperature. Theory and experimental data are in good agreement. There are 6 figures and 12 references: 3 Soviet and 9 non-Soviet. The four most recent English-language references read as follows: R. A. Ferrell. Phys. Rev. Lett., 3, 262, 1959; P. W. Anderson. Phys. Rev. Lett., 3, 325, 1959; J. Bardeen, J. R. Schrieffer. Progress in Low Temp. Phys., 3, Amsterdam, 1961; G. M. Androes, W. D. Knight. Phys. Rev., 121, 779, 1961.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute for Research on Problems of Physics of the Academy of Sciences USSR)

SUBMITTED: November 4, 1961

S/056/62/043/003/051/063
B108/B102

AUTHOR: Abrikosov, A. A.

TITLE: Green's function for electrons in a metal and analysis of the electron spectrum

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 43, no. 3(9), 1962, 1083 - 1086

TEXT: The electron spectrum in a real metal is studied by examining the Fourier representation of the electron Green function

$$G_{\alpha\beta}(\mathbf{r}, t; \mathbf{r}', t') = \int_{-\infty}^{\infty} \frac{d\omega}{2\pi} \int \frac{d\mathbf{k}}{(2\pi)^3} G_{\alpha\beta}(\omega, \mathbf{k}, \mathbf{r}, \mathbf{r}') e^{i\mathbf{k}(\mathbf{r}-\mathbf{r}')-i\omega(t-t')}, \quad (2).$$

The function $G_{\alpha\beta}(\omega,\vec{k},\vec{r},\vec{r}')$ is invariant with respect to the small group of vector $\vec{k}$. On introducing the quantity $Q(x,x')$ which has the properties of invariance as G, and which is given by

$$\int Q_{\alpha\gamma}(x, x'') G_{\gamma\beta}(x'', x') d^4x'' = \delta(x - x') \delta_{\alpha\beta}, \quad (11),$$

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where x = (r,t). The shape of the above mentioned function near the Fermi boundary ($\omega = 0$, $\vec{k} = \vec{k}_0$) is found to be:

$$G_{\alpha\beta}(\omega, \mathbf{k}, \mathbf{r}, \mathbf{r}') \simeq a \sum_{ss'} [\omega - D(\mathbf{k} - \mathbf{k}_0)]_{ss'}^{-1} u_{0\mathbf{k}_0 s}(\mathbf{r}, \alpha) u^*_{0\mathbf{k}_0 s'}(\mathbf{r}', \beta). \quad (15)$$

The pole of this function is determined by

$$\det [\omega\delta_{ss'} - D_{ss'}(\mathbf{k} - \mathbf{k}_0)] = 0, \quad (16)$$

The matrix $D_{ss'}$ can be expressed in terms of unknown constants. Moreover, the Green function has also the property

$$G_{\alpha\beta}(\mathbf{r}, t; \mathbf{r}', t') = [\hat{g}G(\mathbf{r}', -t'; \mathbf{r}, -t)\hat{g}^{-1}]_{\beta\alpha}. \quad (23)$$

The same must hold also for $G_{\alpha\beta}(\omega,\vec{k},\vec{r},\vec{r}')$.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute of Physical Problems of the Academy of Sciences USSR)

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B108/B102

Green's function for electrons...

SUBMITTED: April 23, 1962

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S/056/62/043/003/052/063
B104/B102

AUTHORS: Abrikosov, A. A., Fal'kovskiy, L. A.

TITLE: Theory of electron energy spectrum for metals of the bismuth type

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 43, no. 3(9), 1962, 1089-1101

TEXT: Arsenic, antimony and bismuth have rhombohedral lattices formed when two face-centered sublattices of a cubic lattice are mutually displaced along the diagonal of the cube. First, the electron energy spectrum is calculated for a lattice differing infinitesimally from cubic. Then this lattice is deformed so as to cause mutual displacement of the two sublattices. The displacement results in the metal undergoing a phase transition of the second kind whereby the lattice constant is doubled. The number of carriers diminishes. The effect of such a deformation on the electron energy spectrum is investigated, leading to the formula

$$E_n \sim L^2 \left\{ \int\limits_{\max(f,\gamma)}^{-\mu(0)} d|\Omega| \sqrt{\Omega^2-\gamma^2} + 3 \int\limits_{\max\left(\frac{f}{3},\frac{\gamma}{3}\right)}^{-\mu(0)} d|\Omega| \sqrt{\Omega^2-\frac{\gamma^2}{9}} - \right.$$

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$$-4\int_0^{-\mu(0)} \Omega\, d\Omega \approx -\frac{2}{3} L^2\gamma^2 \ln \frac{|\mu(0)|}{\max(l, \gamma)}\Big\}. \qquad (22),$$

where $\Omega = f - \omega$ are the eigenvalues of the matrix

$$D_{ss'} = \left\| \begin{array}{cccccccc}
f+a\varkappa_z+\Delta & 0 & \frac{b\varkappa_++\beta_+}{\sqrt{2}} & -\frac{b\varkappa_++\beta_+}{\sqrt{2}} & \gamma & 0 & \frac{\delta_+}{\sqrt{2}} & -\frac{\delta_+}{\sqrt{2}} \\
0 & f+a\varkappa_z+\Delta & \frac{b\varkappa_-+\beta_-}{\sqrt{2}} & \frac{b\varkappa_-+\beta_-}{\sqrt{2}} & 0 & \gamma & \frac{\delta_-}{\sqrt{2}} & \frac{\delta_-}{\sqrt{2}} \\
\frac{b\varkappa_-+\beta_-}{\sqrt{2}} & \frac{b\varkappa_++\beta_+}{\sqrt{2}} & f+a\varkappa_z-\Delta & 0 & \frac{\delta_-}{\sqrt{2}} & \frac{\delta_+}{\sqrt{2}} & \gamma & 0 \\
-\frac{b\varkappa_-+\beta_-}{\sqrt{2}} & \frac{b\varkappa_++\beta_+}{\sqrt{2}} & 0 & f+a\varkappa_z-\Delta & -\frac{\delta_-}{\sqrt{2}} & \frac{\delta_+}{\sqrt{2}} & 0 & \gamma \\
\gamma & 0 & \frac{\delta_+}{\sqrt{2}} & -\frac{\delta_+}{\sqrt{2}} & f-a\varkappa_z+\Delta & 0 & \frac{-b\varkappa_++\beta_+}{\sqrt{2}} & \frac{b\varkappa_+-\beta_+}{\sqrt{2}} \\
0 & \gamma & \frac{\delta_-}{\sqrt{2}} & \frac{\delta_-}{\sqrt{2}} & 0 & f-a\varkappa_z+\Delta & \frac{-b\varkappa_-+\beta_-}{\sqrt{2}} & \frac{-b\varkappa_-+\beta_-}{\sqrt{2}} \\
\frac{\delta_-}{\sqrt{2}} & \frac{\delta_+}{\sqrt{2}} & \gamma & 0 & \frac{-b\varkappa_-+\beta_-}{\sqrt{2}} & \frac{-b\varkappa_++\beta_+}{\sqrt{2}} & f-a\varkappa_z-\Delta & 0 \\
-\frac{\delta_-}{\sqrt{2}} & \frac{\delta_+}{\sqrt{2}} & 0 & \gamma & \frac{b\varkappa_--\beta_-}{\sqrt{2}} & \frac{-b\varkappa_++\beta_+}{\sqrt{2}} & 0 & f-a\varkappa_z-\Delta
\end{array} \right\|$$

$$f = vu_z + \zeta w, \quad \gamma = cu_z, \quad \beta_\pm = eu_\pm = e(u_y \pm iu_x), \quad \delta_\pm = du_x. \quad (7),$$

$L \sim bK$. K is a quantity of the order of the inverse lattice parameter, $\vec{u}$ is the deformation vector, u_{ik} is the deformation tensor. There are 5 figures and 1 table.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute of Physical Problems of the Academy of Sciences USSR)

SUBMITTED: April 23, 1962

44240

S/056/62/043/006/045/067
B187/B102

AUTHORS: Abrikosov, A. A., Gor'kov, L. P.

TITLE: The nature of impurity ferromagnetism

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 43, no. 6(12), 1962, 2230-2233

TEXT: The ferromagnetism discovered by Matthias et al. (Phys. Rev. 115, 1597, 1959; Phys. Rev. Lett. 1, 44, 92, 1958) in nonmagnetic metals doped with paramagnetic atoms was first explained by the exchange interaction between the impurity atoms and the conduction electrons. This concept was refuted, however, in a paper by Yosida (Phys. Rev. 106, 893, 1957) who argued that such an interaction cannot cause a uniform polarization of the electron spin. The latter is assumed to occur only in the neighborhood of the impurity atoms and to decrease rapidly with the distance from the atom concerned; but this concept is not correct as the decrease does not take place rapidly. The contribution of all impurity atoms to polarization has therefore to be taken into account. The electron density with different spin orientation as a function of the number of randomly distributed

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impurity atoms is calculated on the basis of this concept and with the aid of a formula of Yosida. It is shown that spin polarization of the impurity atoms causes uniform electron polarization. Furthermore, the thermodynamic properties of this model are studied. The Curie temperature is determined from the internal and free energies of the system. It is found to be proportional to the impurity concentration. For temperatures above the Curie temperature a formula is given for the paramagnetic susceptibility.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute of Physical Problems of the Academy of Sciences USSR)

SUBMITTED: July 3, 1962

L 10205-63 EWP(q)/EWT(m)/BDS--AFFTC/ASD--JD

ACCESSION NR: AP3000061 S/0056/63/044/005/1632/1639

53
52

AUTHOR: Abrikosov, A. A.

TITLE: On the number of "free carriers" in bismuth-type metals at high temperatures

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SOURCE: Zhurnal eksper. i teoret. fiziki, v. 44, no. 5, 1963, 1632-1639

TOPIC TAGS: metals, electronic properties, free carriers, bismuth-type metals, high temperatures

ABSTRACT: The number of free carriers in bismuth-type metals is investigated on the basis of the electron spectrum obtained for such metals in an earlier paper (Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 43, 1089, 1962). The conditions for the appearance of open energy surfaces are established precisely. It is shown that as a result of the appearance of open energy surfaces for deep energy levels, the number of carriers at high temperatures may be close to that in semiconductors with intrinsic conductivity. It is noted that all the characteristic energies of conduction, namely the Debye frequency, the

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L 10205-63
ACCESSION NR: AP3000061

Fermi energy, and the powers of the exponential terms in the expressions for the numbers of the carriers are of the same order of magnitude. Furthermore, the exponential laws represent rapid variation and the estimates of the corresponding quantities require exact values of the power. Finally, the melting point of bismuth and that of antimony are of the same order of magnitude as characteristic energies. All this makes it difficult to predict in which temperature ranges the different laws apply. Orig. art. has: 21 formulas.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute of Physics Problems, Academy of Sciences SSSR)

SUBMITTED: 11Dec62 DATE ACQ: 12Jun63 ENCL: 00

SUB CODE: PH NR REF SOV: 001 OTHER: 003

bm/kw

Card 2/2

L 13567-63 EWT(1)/BDS/EEC(b)-2/EWD-2 AFFTC/ASD/ESD-3/APGC/AFWL/SSD

ACCESSION NR: AP3003137 S/0056/63/044/006/2039/2057 65 61

AUTHOR: Abrikosov, A. A.

TITLE: Dielectric constant of bismuth-type metals in the infrared region

SOURCE: Zhurnal eksper. i teor. fiziki, v. 44, no. 6, 1963, 2039-2057

TOPIC TAGS: bismuth-type metals, dielectric constant, Fermi surface, energy transitions gas model, electron-electron interactions, electron-phonon interactions

ABSTRACT: The dielectric constant of bismuth-type metals is determined from their electron spectrum. This supplements and earlier study made by the author (ZhETF v. 44, 1632, 1963) of the influence exerted on the number of free carriers in such metals by the deep electron energy levels corresponding to open equal-energy surfaces, which can be conveniently investigated in the infrared region. It is shown that the dielectric tensor has in a large frequency region real positive frequency-independent principal values on the order of 100, and becomes complex starting with several hundredths or one-tenth of an electron volt. The components of the dielectric tensor have singularities at some values of the frequency. It is shown also that the large dielectric constant leads to an appreciable decrease in the electron-electron and electron-phonon

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ACCESSION NR: AP3003137

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interactions, so that the gas model can be applied to these metals. "In conclusion, I thank I. M. Lifshits and L. P. Pitayevskiy for a discussion of the work." V. P. Silin is also credited with a pertinent remark. Orig. art. has: 62 formulas.

ASSOCIATION: Institut fizicheskikh problem Akademii nauk SSSR (Institute of Physics Problems, Academy of Sciences SSSR)

SUBMITTED: 15Jan63 DATE ACQ: 23Jul63 ENCL: 00

SUB CODE: 00 NO REF SOV: 009 OTHER: 002

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L 17346-63 EWT(l)/EWP(q)/EWT(m)/BDS/EEC(b)-2 AFFTC/ASD/ESD-3/IJP(C) GG/
ACCESSION NR: AP3007101 JD/K S/0056/63/045/003/0746/0749

AUTHOR: Abrikosov, A. A. 64 63

TITLE: Absence of superconductivity in bismuth-type metals

SOURCE: Zh. eksper. i teoret. fiziki, v. 45, no. 3, 1963, 746-749

TOPIC TAGS: bismuth superconductivity, bismuth superconductivity absence

ABSTRACT: An analysis is presented to support the interpretation of the absence of superconductivity in bismuth-type metals as a result of weakening of electron and phonon interaction. Two types of elementary electron lattice interactions, the immediate Coulomb interaction and the interchange of phonons, are considered. In the interchange of phonons, two cases are analyzed: the electron 1) remaining in its own closed region of the Fermi surface in inciting a phonon or 2) changing over to another region. Expressions for interactions are deduced for both cases. The interaction with electrons remaining in their region is nearly isotropic in relation

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ACCESSION NR: AP3007101

to the directions of the wave vector, while the changeover interaction is effective only within narrow solid angles. The Coulomb interaction is also discussed for two cases, namely, for 1) electrons remaining in their regions and 2) two electrons from different regions interchanging their regions. The limitation to narrow angles in the second case of phonon interchange applies also to Coulomb interactions. Both types of interchange interactions, therefore, have the same effect. On these premises, the problem of actual superconductivity is treated according to the method used by Cooper, with the conclusion that superconductivity, although not excluded in principle, would occur only at temperatures unattainable experimentally. Thus the absence of superconductivity in metals of the bismuth type is found to be due to their peculiar pattern of electron spectrum or, in the final analysis, to the crystal structure of these metals. Orig. art. has: 11 formulas.

ASSOCIATION: Institut fizicheskikh problem AN SSSR (Institute of Physical Problems, AN SSSR)

SUBMITTED: 20Mar63 DATE ACQ: 08Oct63 ENCL: 00

SUB CODE: PH NO REF SOV: 006 OTHER: 000

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S/0056/63/045/006/2038/2047

ACCESSION NR: AP4009130

AUTHOR: Abrikosov, A. A.

TITLE: The conductivity of strongly compressed matter

SOURCE: Zhurnal eksper. i teoret. fiziki, v. 45, no. 6, 1963, 2038-2047

TOPIC TAGS: conductivity, high pressure, conductivity of compressed matter, conductivity of compressed solids, conductivity of compressed liquids, conductivity of compressed hydrogen, Fermi surface, Debye temperature, conduction electron scattering, electron electron scattering, electron phonon scattering, electron impurity scattering, ultrarelativistic electrons

ABSTRACT: The conductivity of strongly compressed matter in different temperature and pressure intervals is studied with the aim of separating the contributions of each type of conduction electron scattering to the total conductivity. The conductivity components due to scattering by impurities, phonons, and electrons are determined for the solid phase, and it is shown that strongly compressed

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ACCESSION NR: AP4009130

solid hydrogen has a much higher conductivity than other solid elements, owing to its closed Fermi surface. The conductivity of various liquid modifications is studied for the cases when the electrons and nuclei are either degenerate or have a Boltzmann distribution. The corrections that must be made to the derived formulas when the conduction electrons are ultrarelativistic are also derived. Orig. art. has: 33 formulas.

ASSOCIATION: Institut fizicheskikh problem AN SSSR (Institute of Physical Problems, AN SSSR)

SUBMITTED: 18Jun63 DATE ACQ: 02Feb64 ENCL: 00

SUB CODE: PH NO REF SOV: 003 OTHER: 001

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ACCESSION NR. AP4031171 S/0056/64/046/004/1464/1469

AUTHOR: Abrikosov, A. A.

TITLE: The lower critical field of thin layers of superconductors of the second kind

SOURCE: Zh. eksper. i teor. fiz., v. 46, no. 4, 1964, 1464-1469

TOPIC TAGS: superconducting thin film, superconductor of second kind, transition temperature, mixed state superconductor, Abrikosov theory, superconductivity

ABSTRACT: Thin layers of superconductors of the second kind have been investigated in the light of Abrikosov's mixed-state-theory by using Ginzburg-Landau equations. The lower critical field, at which the supercurrent filaments begin to penetrate into the film, was determined. Curves of the dependence of the magnetic moment on the field show a break at H_{C1} and a vertical tangent on the side of the increasing field intensities. The results of theoretical calculations could not be checked with experimental data because no measurements of

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